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Anthropogenic Water Uses and River Flow Regime Alterations by Dams

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Dams and impoundments have been designed to reconcile the conflict between patterns of anthropogenic water uses and the temporal variability of river flows. Over the past seven decades, population growth and economic development led to a marked increase in the number of dams, and nowadays unregulated free-flowing rivers are rare in developed countries. Despite alterations of the hydrologic cycle have been observed ubiquitously in different regions of the world, a systematic view on the impact of river regulation on flow regime as driven by variable regulation capacities and heterogeneous uses is lacking. Therefore, improving our understanding of the influence of dams and reservoirs on hydrologic regimes plays a key role in water planning and management, possibly allowing an optimized exploitation of water resources and the maintenance of key ecosystem functioning. In this study, a physically based analytic approach is combined to extensive hydrologic data to investigate natural flow regime alterations downstream of dams in the Central-Eastern United States. The considered case studies span a wide range of climatic settings and different water uses, including flood control, water supply and hydropower production. The analysis shows that flood control through dams decreases the intra-seasonal variability of downstream flows and leads to the homogenization of regional flow dynamics. The extent of such effect is controlled by the storage capacity of reservoirs, properly scaled to the average incoming streamflow. Conversely, our analyses reveal that reservoirs used for water supply behave in a completely different manner, as they increase daily streamflow variability downstream of dams and enhance the inter-catchment heterogeneity at regional scale, especially during winter and spring. This effect is particularly enhanced in cases where the amount of water withdrawn from the lake is significant. Over the last decades, the supply of fresh water to sustain population growth has become a major concern at global scale. Accordingly, the number of reservoirs devoted to water supply increased by 50% in the US. Given the distinctive effect of reservoirs used for water supply (in terms of enhanced flow variability and catchment diversification), the observed increase of their number foreshadows a possible shift in the cumulative effect of dams on river regimes at regional and global scales.